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To what Extent do Kolkata's Star Hotels Practice Sustainable Waste Management

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Abstract

Background*: The hospitality industry, a major contributor to global environmental issues, is under increasing pressure to adopt sustainable practices. While the concept of sustainability has gained momentum worldwide, the extent of its adoption in emerging urban centres like Kolkata remains unclear.* **Objective:** *The objectives are to explore and implement innovative waste management technology and practices in Kolkata star hotels to reduce environment impact and maximize resource recovery, where also identify and addressing the barriers hindering their adoption to promote sustainable waste management in hospitality sector.* **Methodology:** *This study explored sustainable waste management practices in five stars hotels in Kolkata. In-depth interviews and focus group discussions with supervisory staff from renowned hotel chain were done. The research adopted a qualitative design, with a total sample size of 30 participants. Data was analysed thematically to identify trends.* **Results:** *Kolkata's hotel industry faces challenges in sustainable waste management due to financial constraints, technological limitations, infrastructure gaps, and guest behaviour. Progress has been made through waste segregation, plastic reduction, and digital tools. Overcoming these challenges requires government support, technological advancements, community engagement, and behavioural change programs. By integrating waste reduction, recycling, and resource recovery, hotels can establish a sustainable circular economy model.* **Conclusion:** *Continuous monitoring, innovation, and collaboration are circular for long-term success.*

Keywords: Hospitality industry, sustainable waste management, environmental impact, Kolkata, metropolitan

Introduction

This study investigates the implementation of sustainable waste management practices in Kolkata star-rated hotels, examining the alignment with international sustainability standards and local waste regulations. The hospitality sector is a major contributor to global environmental issues, generating considerable waste and carbon emission (Gössling et al., 2012; Bohdanowicz, 2006; Jones et al., 2014; Pirani & Arafat, 2014; Ricaurte, 2011; Kasim, 2009). While the global hospitality industry is increasingly embracing sustainability, its adoption in developing urban centre like Kolkata presents a unique challenge. As urbanization and tourism boom, the need for efficient waste management solutions becomes more critical (Hoornweg & Bhada-Tata, 2012; World Bank, 2018; Gupta et al., 2015). However, there is a notable gap in research exploring the implementation of sustainable practices in emerging urban markets, especially within Kolkata's hospitality sector. Scholars highlights a renewed global weight on sustainability in hotels. It starts mainly since the COVID-19 pandemic which exposed vulnerabilities

PUSA Journal of Hospitality and Applied Sciences, 2025; 11(2) : 27-37
ISSN 2395-020X (P); e-ISSN 2583-2700 (O)
NAAS Score: 3.49

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in waste management systems. Cami, (2025); Abad, M and Reyes, (2025) conducted a study about basic recycling measures towards integrated circular economy strategies in the hotel industry for environmental practice through mixed-method. Their work highlights the growing influences of the Sustainable Development Goals (SDGs). SDG 12 is responsible consumption and production.

Papadimitriou et al. (2025) studied how artificial intelligence (AI) works in advancing sustainability in green hotels. It indicates AI is increasingly used to optimize energy consumption, minimizing food waste, and strengthen environmental, social, and governance (ESG) reporting. Hotel sustainability and consumer expectations are closely related. Consumer expectations are crucial. Guests increase their expectations about visible green initiatives such as water conservation, food waste reduction, and plastic elimination. These initiatives significantly impact brand image (Ballester et al., 2025). Waste management improvement is increasing accelerate due to innovation of technology. The growing adoption of digital product passports and smart waste tracking systems allow for more precise monitoring of resource flows, Perna et al. (2024). It helps to enhance regulatory compliance and consumer trust in eco-certification programs. Smart technologies can transform waste management in hospitality, positioning hotels as drivers of broader urban sustainability transitions (Altendorfer et al., 2024).

Against this backdrop, Kolkata provides an important case study. While global hotel chains are progressively adoption structured sustainability frameworks, the degree to which these practices are localized and implemented within city's star-rated hotels remain underexplored. This study contributes to filling this research gap by examining how hotels in Kolkata interpret, adapt, and apply sustainable waste management practices in line with international standards, while also navigating local regularity, economic, and cultural challenges.

Hospitality industry is significant contributor to environmental degradation. Hospitality businesses are focusing on sustainability to balance profit with environment responsibility. The hospitality industry is taking attention financial success with ecological balance. Gupta et al. (2015), Pires and Chang (2011), Singh and Ordoñez (2016), and Wilson et al. (2006) highlighted the sustainable operational practices urgently need in waste management. Bohdanowicz

(2006), Mensah (2006), and Chan and Wong (2006) found that luxury hotels often lag in incorporate sustainable practices due to perceived high costs and limited awareness. Urban hospitality hubs meaningfully contribute sustainable waste management. Bohdanowicz (2005) and Kasim (2009) highlight the responsibility of urban hotels in promoting sustainable practices like recycling, composting, and waste-to energy initiatives. Yet, emerging economies face footraces from weak institutions and infrastructure. Singh and Chandel (2017) studied how Indian urban hotels manage waste. They found that practices like separating waste and recycling were not enforced consistency. This problem is like what was found in Kolkata.

Policy frame works significantly shape waste management practices in the hospitality sectors. Rana et al. (2025) explores how local regulations influence hotel practices and advocate for practice government policies to promote sustainability. People need eco-friendly tourism. Sustainability is a major factor for hotels. Studies have shown that money problems, lack of training, and not knowing enough about waste management are big reasons why it is hard to manage waste effectively. Guerrero et al. (2013) suggest capacity-building and technology-driven solutions to address these issues.

Umumararungu and Njenga (2025) found that hotels in South Asia have been a great job of managing waste sustainably. They use technology and work with local communities to achieve this. The hospitality industry is a big part of polluting the environment. It is starting to understand that it needs to manage waste sustainable way. Even though more people are aware of this and want to do things better, there are still a lot of things we do not know.

There is lack of research on innovative technologies and practices related waste management practices to improve waste management of Kolkata's star hotels. How do these technologies be effectively integrated into existing operations? How can innovative technologies and practices be effectively integrated into the waste management operations of Kolkata's star hotels to minimize environmental impact and maximize resource recovery? What are the barriers and challenges to the adoption of innovative waste management technologies and practices in Kolkata's star hotels, and how can these be addressed to promote sustainable waste management.

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PUSA Journal of Hospitality and Applied Sciences, 2025; 11(2) : 27-37
ISSN 2395-020X (P); e-ISSN 2583-2700 (O)
NAAS Score: 3.49

Objectives:
- To identify, evaluate innovative technologies and practices that can be effectively implemented in Kolkata's star hotels to optimize waste management processes, reduce environmental impact, and maximize resource recovery.
- To analyse the barriers and challenges hindering the adoption of innovative waste management technologies and practices in Kolkata's star hotels, and propose strategies to overcome these obstacles and promote sustainable waste management practices within the hospitality sector.

Methodology

Research Design: The qualitative research has been applied to explore waste management practices in five-star hotels of Kolkata Metropolitan area. A qualitative approach has been selected due to an in-depth understanding of the attitudes, perceptions, and operational practices of hotel staff, enabling rich insights into environmental sustainability issues (Creswell & Poth, 2018).

Locale: The study area was in the Kolkata metropolitan area which is one of India's largest urban centres and a growing hub of luxury hospitality. In this area, there are international and national hotel chain exist and local regulatory provides framework for global sustainability in waste management regulations.

Sampling Design: A purposive sampling technique was employed to select five renowned five-star hotels. It is included leading international and national chains. A total of 30 supervisory-level staff were selected as participants, since they are directly engaged in waste handling, monitoring, and sustainability operations. Purposive sampling was justified to ensure the inclusion of information-rich cases that represent diverse waste management strategies withing the luxury hospitality segment (Patton, 2015).

Tools and Technique: Two primary qualitative tools were used for data collection. In-depth interviews: semi-structure interviews were conducted with supervisory staff to elicit detailed accounts of their practices, challenges, and perceptions regarding waste management. Interviews lasted approximately 45-60 minutes and were conducted in designated meeting rooms within the hotels to ensure privacy and minimize workplace disruptions. Focus group

discussions (FGDs): Facilitated discussions with groups of 5-6 participants were organized in hotel conference rooms to encourage collaborative dialogue and uncover shared challenges and innovative practices. FGD were audio-recorded (with consent) using Sony ISD- UX570 digital recorders (Sony Corporation, Japan), and transcribed verbatim. These techniques allowed triangulation of findings by combining individual reflections with group perspectives, thereby strengthening the validity of the results (Flick, 2018). Semi-structured interviews and focus group discussions are widely recognized in hospitality and sustainability research for capturing both individual and collective perspectives (Silverman, 2020).

Data Analysis and Statistical Analysis: The data was analysed using thematic analysis, following Braun and Clarke (2008) six-phase framework: familiarization, coding, theme development, review, definition, and reporting. Content analysis was also applied to systematically identify specific references to waste segregation, recycling initiatives, food waste management, and regulatory compliance. NVivo 12 software (QSR International, Australia) was used to code and organize qualitative data. As this was an exploratory qualitative study, descriptive statistics were used to summarize participants demographics and occurrence of specific practices.

Results and Discussion

Table 1: Sociodemographic Characteristics of Study Participants (N=30)

Variable	Category	n	%	Mean ± SD
Age group (years)	18–25	10	33.3	—
	26–33	5	16.7	—
	34–41	7	23.3	—
	42–60	8	26.7	—
Age (overall)	—	30	100	34.43 ± 11.63
Gender	Male	20	66.7	—
	Female	10	33.3	—
Marital status	Single	12	40.0	—
	Married	18	60.0	—
Educational level	Higher Education (10+2)	5	16.7	—
	Graduate	18	60.0	—
	Post graduate	7	23.3	—

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ISSN 2395-020X (P); e-ISSN 2583-2700 (O)
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	15,000–20,000	12	40.0	—
Income (monthly, INR)	20,001–25,000	5	16.7	—
	25,001–30,000	6	20.0	—
	≥ 30,001	7	23.3	—
Income (overall)	—	30	100	23,833.33± 6046.1
Residence	Urban	18	60.0	—
	Semi-urban	12	40.0	—

Source: Researchers' Primary Data

Description of sociodemographic characteristics: The table 1 describes the sociodemographic of 30 participants with a mean age of 34.43 years (SD=11.63), reflecting a relatively young to middle-aged population. Participants were fairly distributed across age groups, with the highest representation in the 18-25 years group (33.3%), followed by 42-60 years (26.7%), 34-41 years (23.3%), and 26-33 years (16.7%). This suggests a balanced mix of younger and older adults, providing a diverse age perspective. In terms of gender, two-thirds were male (66.7%) and one-third female (33.3%), indicating a male-dominated sample. Regarding marital status, the majority were married (60%) and 40% were single. It indicates a stronger representation of family-oriented participants. Education levels showed that most participants were well-educated. This points toward a relatively high educational background within the sample. Economic distribution revealed that the mean monthly income was Rs. 23,833.33 (SD=6046.1). The largest group (40%) earned between Rs. 15,000- 20,000, followed by 20% in the Rs. 25,001- 30,000, 23,3% earning ≥ Rs. 30,001, and a smaller segment (16.7%) between Rs. 20,001- 25,000. These figures suggested that most participants belonged toa lower-middle to middle- income category. Regarding residence, the majority lived in urban areas (60%), and 40% were from semi-urban regions, indicating some degree of socioeconomic diversity in the study context.

The spread across different age groups strengthens the study by incorporating perspectives from both younger and more mature adults. The predominance of male participants may limit gender-balanced interpretations and could influence perspectives in areas where gender plays a significant role. A higher proportion of married participants might suggest more stability and family-related insights compared to single participants. The relatively high level of education across participants could influence responses, particularly in studies involving awareness, knowledge, or cognitive skills. The income distribution shows participants were not from very low-income groups but clustered around the lower-middle to middle-income segment, which may affect generalizability to higher or lower extremes of society. A predominantly urban sample may introduce an urban bias, though inclusion of semi-urban participants adds some representational balance.

Table 2: *Themes, Themes-Related Content, and Interview Question on Sustainable Waste Management Practices in Kolkata's Five-Star Hotels*

Theme	Theme-related Content	Sample Interview Question
Waste segregation at source	Hotels use colour-coded bins (green, blue, red) for biodegradable, recyclable, and hazardous waste. Staffs are trained to sort waste accordingly, ensure regulatory compliance.	Please elaborate on the specific waste segregation and training practices
Recycling initiatives	Hotels recycle plastic, paper, and glass often partnering with certified recycling centres or NGOs.	What strategies optimize material recycling?
Reduction of single-use-plastic	Hotels are swapping single-use plastic for sustainable alternatives like bamboo straws and reusable dispensers.	What measures are in place to curb single-use plastic use?
Digital solutions to minimize paper waste	Digital technologies like e-bills, QR code, and electronic communication have dramatically reduced paper usage.	How have digital tools reduced paper consumption?
Food waste management programs	Partnering with food redistribution platforms enables us to donate surplus food to NGOs, reducing waste and fostering social responsibilities.	How do food waste programs reduce waste and build community?
Employee training and awareness campaigns	Regular staff training and guest awareness campaigns promote sustainable waste management.	How can training programs cultivate a sustainable organization culture?
On-site waste processing facilities	Hotels use compactors, bio-digestors, and balers to reduce volume.	How do hotels process their waste on-site?

Monitoring and reporting	Hotels maintain detailed waste records and conduct periodic audits to enhance sustainability.	What monitoring and reporting system ensure accountability in waste management?
Challenges in sustainability	Hotels face significant challenges, including high cost, inconsistent guest waste segregation, and limited recycling infrastructure.	What obstacle hinder sustainable waste management?

Source: Researchers' Primary Data

Elaboration of thematic findings: As per table 2, the qualitative data revealed a diverse range of sustainable waste management practices across Kolkata's five-star hotels. Waste segregation at source emerged as fundamental strategy, with hotels employing colour-coded bins (green, blue, and red) to separate biodegradable, recyclable, and hazardous waste. Staff training was central to ensuring compliance and efficiency. Recycling initiatives were also widely practiced, often in collaboration with certified recycling centres or NGOs. Hotels recycled plastics, glass, and paper to reduce environmental burden. Partnership with external agencies not only ensured compliance with local regulations but also enhanced corporate sustainability image. Reduction of single-use plastic was notorious as a major sustainability priority. Several hotels adopted bamboo, straws, refillable dispensers, and other eco-friendly alternatives. It is used to reduce reliance on plastics. This shift aligns with the global movement in tourism and hospitality.

Many hotels use electronics bills, QR codes, and online communication systems to minimize paper waste. Hotels use Food waste management programs as recurring theme. Hotels along NGOs redistribute surplus food for donation, it leads reducing landfill waste and, also supporting community welfare. Employee training and awareness campaigns were major concerned as enables of sustainable practices. Supervisory staff tressed that repeated training, coupled with guest awareness initiatives, educated a sustainability-oriented organizational culture. Hotels deployed compactors, bio-digestors, and balers to reduce waste volume and improve efficiencies at waste site. Monitoring and reporting mechanisms were identified which leads to accountability. Hotels recorded of waste generation and conducted periodic audits. At last, challenges in sustainability were noted. It included the high-cost infrastructure, limited recycling

networks, and inconsistent participation from guests.

This summarizes themes which are related to sustainable waste management practices in hotels. Colour-coded bins are implemented to segregated biodegradable, recyclable, and hazardous waste. Staff training helps for sorting and regulatory compliance. These directly support SDG 12: Responsible consumption and production by reducing landfill dependence. Plastic waste is dangerous waste, to reduce that waste, hotels are applying sustainable alternatives and implementing measures to control single-use plastics which is aligning with SDG 14: Life below water and SDG 15: Life on land (United Nations, 2015).

Digital technologies such as e-bills and QR codes have significantly reduced paper usage, reinforcing SDG 9: Industry, innovation, and infrastructure and SDG 13: Climate action. Similarly, food waste management programs and partnerships with NGOs contribute to both waste reduction and social responsibility, supporting SDG 2: Zero Hunger. Regular staff training and guest awareness campaigns foster a culture of sustainability (Rhou and Singal, 2020) aligning with SDG 4: Quality education. On-site waste processing facilities and monitoring systems enhance accountability, furthering SDG 11: Sustainable cities and communities (United Nations, 2015). However, high costs, inconsistent guest waste segregation, and limited recycling infrastructure remain significant challenges.

Table 3: Themes, Themes-Related Content, and Sample Interview Questions on Barriers, Benefits, and Future Directions of Sustainable Waste Management in Kolkata's Five-star Hotels

Theme	Theme-related Content	Question
Financial constraints	High upfront costs, uncertain ROI, and budget constraints in Kolkata's competitive hospitality market.	How can hotels finance sustainable waste management initiatives?
Technological accessibility	Limited access to advanced waste management technologies and skilled operators.	How can technology improve waste management in Kolkata's hotels?
Regulatory barriers	Regulatory hurdles and lack of governments support hinder technology adoption.	How can government policies promote sustainable waste management in hotels?

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ISSN 2395-020X (P); e-ISSN 2583-2700 (O)
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Operational challenges	Space limitations, system integration difficulties, and staff retraining needs hinder operational implementation.	How can hotels in tight urban spaces optimize waste management?
Cultural and behavioural barriers	Staff and guest resistance to change, limited awareness of sustainable waste management benefits, and inconvenience associated with new practices.	How to boost guest and staff engagement in hotel waste reduction initiatives?
Guest perception and participation	Visible waste management processes can detract from the luxury experience, and guest participation in recycling or segregation in often low without clear communication.	How can we encourage guests to adopt sustainable practices?
Current benefits	Minimize environmental impact through responsible waste management and recycling.	What are the environmental and economic benefits of current hotel waste management practices?
Current drawbacks	High implementation costs, unreliable waste collection, inconsistent participation, limited space, and lack of advanced local recycling facilities.	What challenges prevent hotels from consistently implementing sustainability initiatives?
Plans (future)	Sustainable practices like food redistribution, on-site composting, and eco-friendly guest engagement.	How are hotels innovating waste management?

Source: Researchers' Primary Data

The qualitative findings (table 3) revealed multiple barriers, benefits, and future pathways which shapes sustainable waste management practices in Kolkata's five-star hotels. Financial constraints appeared as a recurring challenge. High upfront investment costs for advanced technologies were also major factor to maintain sustainability in waste management as it is directly related returns on investment (ROI). Technological accessibility was another a critical limitation. Participants stressed that the scarcity of advanced waste processing facilities and the lack of skilled operators hampered to progress sustainability. Regulatory barriers again delayed the process. Several participants noted that there are gaps in government support and municipal regulations, which makes compliance challenging.

Operational challenges were also extensively stated. Hotels in densely populated urban areas like Kolkata often struggle with limited space for waste segregation. It is also problem of storage, and processing facilities. Integrating new systems into existing operations required retraining staff. Retraining staff was seen as disruptive and costly undertaking. These challenges echo with prior research emphasizing that urban hospitality operations often face infrastructural bottlenecks. It creates to restrict sustainable practice implementation (Rhou & Singal, 2020).

Cultural and behavioural barriers appeared in the form of resistance from both staff and guests. Participants described limited awareness of the benefits of sustainable practices and perceived inconvenience associated with waste segregation. Closely related to this were issues of guest perception and participation. Hoteliers expressed concern that visible waste handling practices could detract from the luxury experience. Guest participation in segregation and recycling was also reported to be inconsistent unless clearly communicated. Despite these barriers, participants also identified several current benefits of sustainability programs. Hotels reported that even partial implementation of waste segregation, recycling, and food redistribution helped minimize environmental impacts and generated reputational benefits. However, current drawbacks included recurring complaints about high costs, unreliable waste collection systems, and limited infrastructure for recycling. Finally, participants highlighted plan for sustainability food redistribution to NGOs, on-site composting, and increased guest engagement through eco-friendly communication.

This provides a comprehensive overview of challenges and opportunities facing sustainable waste management in Kolkata's hotel industry. The major barrier is financial. Sustainable waste management needs high cost and there is no guarantee of returns. This is one of the causes of discourage of sustainability investments. This challenges SDG 8: Decent and economic growth. Slowing advancement toward SDG 9 due to technological limitations; limited access to advanced processing equipment and skilled human beings, which restrict progress. Hindering progress toward SDG 16: Peace, justice, and strong institutions due to regulatory hurdles; inadequate supportive government policies, and compound these issues. Operations barrier is limited space in urban hotel, which create further challenges, impacting SDG 11. Another hinders are cultural resistance from staff and

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ISSN 2395-020X (P); e-ISSN 2583-2700 (O)
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guest which create low participation in segregation; relates SDG 12 (United Nations, 2015). There are challenges, but innovations such as food redistributions, on-site composting, and eco-friendly guest engagement can accelerate progress on SDG 2 and SDG 13.

Table 4: Innovative Technologies and Practices in Sustainable Waste Management among Five-Star Hotels in Kolkata

Theme	Theme-Related Content
Food waste management	Food waste digesters convert organic scraps into bio-compost. Organic waste converters (OWCs) process both wet and dry waste into manure.
Waste segregation	AI-powered smart sensors for automated waste sorting into recyclable, compostable, and residual categories. IoT-enabled waste bins for optimized collection scheduling and notification.
Energy recovery	Biodigesters harness organic waste and wastewater, transforming them into clean biogas for energy.
Water treatment	MBR (Membrane Bioreactor) systems purify waste water for landscaping and cleaning.
Plastic waste management	Plastic shredders recycle waste into reusable materials.
Data-driven practices	Digital food waste tracking systems optimize procurement by analysing waste trends.
Collaborative efforts	Partnering with waste management agencies for responsible disposal and recycling
Sustainability outcomes	Reduced landfill contributions by 30% over the past years. Saved 15% monthly on energy costs through biogas utilization

Source: *Researchers' Primary data*

Table 4 summarizes a complete overview of innovative technologies and practices which are adopted by five-star hotels in Kolkata to strengthen sustainable waste management. These evolving solutions highlight that the hospitality sector's move toward technologically driven, data-supported, and collaborative approach. Participants reported that food waste management technologies, such as food waste and organic Waste Converters (OWCs) are most important for sustainable waste management. These machines convert organic scrap into compost. It helps reducing significantly food waste that would otherwise end up in landfills. Waste segregations have also progressed from manual to AI and IoT-enabled systems. Participants described the use of smart bins can detect waste types and notify staff for optimize collection.

The crucial innovations were energy recovery and biodigesters. Hotels save up to 15% in energy costs through transforming organic waste and waste water into biogas. It is reducing their reliance on fossil fuels. The use of Membrane Bioreactor (MBR) system allows hotels to recycle wastewater for landscaping, cleaning, and non-potable use. This innovation is vital in Kolkata where scarcity is a pressing issue. Plastic waste management has been recycled into reusable materials, which creates sustainable environment protection.

Data- driven practices are another type of innovation in food waste management. Hotels can analyse waste pattern deploying digital food waste tracking systems. It helps to optimize procurement, ensuring that surplus food and perishable items are better managed. Hotels also underscored collaborative efforts, partnering with municipal bodies, waste management agencies, and NGOs to handle recycling and safe disposal.

Participants observed significant sustainability outcomes from these initiatives. It is including reduced landfill contributions nearly 30% in recent years. It is also measurable financial savings from energy recovery systems. Such evidence reflects a growing synergy between environmental responsibility and economic efficiency. It is also reinforcing the alignment with Sustainability Goals (SDGs 6,7,11,12, and 13). These findings underscore the increasing role of technology-enabled and collaborative practices in transforming waste management within luxury hospitality sector. By embedding such innovations, Kolkata's five-star hotels are positioning themselves as leaders in sustainable urban hospitality.

This reveals the technological innovation and sustainable practices exist significant opportunities for addressing waste management challenges and supporting circular economy principles. AI- and IoT- enabled segregation systems; biodigesters, and digital waste tracking are reshaping efficiency in operations; strengthening SDG 9 and SDG 12. Supportive policy frameworks could further accelerate adoption, directly linked to SDG 16. Rising public awareness fosters behavioural change, which supports SDG 4 and SDG 12 (United Nations, 2015). Such innovations hold potential for environmental and financial benefits, particularly when scaled effectively in developing economies, contributing to SDG 8 and SDG 13.

PUSA Journal of Hospitality and Applied Sciences, 2025; 11(2) : 27-37
ISSN 2395-020X (P); e-ISSN 2583-2700 (O)
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Table 5: Innovative Waste Reduction Strategies Adopted by Five-Star Hotels in Kolkata

Theme	Theme-Related Content
Water-saving technologies	State-of-art-dishwashers recycle rinse water and optimize water usage based on load size and soil levels. Water-saving fixture and conservation programs, like towel/linen reuse, are implemented in guest rooms and public areas.
Sustainable packaging	Reuse glass water bottles, biodegradable and compostable containers for room service and take away, elimination of style-use plastic packaging
Food waste management	Implement on-site composting to transform food waste into nutrient rich compost for landscaping, donate surplus food to local charities, repurpose leftover for staff meals, optimize food preparation practices to minimize waste
Recycling and upcycling	Recycling stations for segregation paper, plastic, and glass. collaboration will local artisans to upscale fabric scraps and glass into decorative items. Segregated waste is sent to recycling facilities for reuse.
Waste water recycling	On-site waste water treatment for laundry and kitchen operation. Treated wastewater is required for cooling systems, reducing fresh water dependency.
Digitalization for paper reduction	Adopt digital solutions: Implement electronic check-ins, e-bills, and QR code menus to reduce paper consumptions. Digital operations: Transitions to digital check-ins, e-bills, QR code menus to minimize paper waste.
Energy efficient practices	Implementing energy-efficient LED Lighting systems, promoting energy conservation practices among staff and guests, embracing sustainable practices to optimize energy efficient in hotel operations.
Staff and guest awareness	Staff training on sustainable practices and resource efficiency, guest education on sustainability goals through in room materials and events, guest-engagement in waste reduction initiatives.

Source: Researchers' Primary Data

Table 5 highlights innovative waste reduction strategies adopted by five-star hotels in Kolkata, reflecting a holistic approach to sustainability. Water-saving technologies, state-of-art dishwashers and towel/ linen reuse programs, align with global best practices in resource conservation and contribute directly to SDG 6 (Clean Water and Sanitation). Sustainable packaging has emerged as a priority, with hotels replacing single-use plastics with biodegradable containers and reusable glass bottles, supporting SDG12 (Responsible Consumption and Production).

Food waste management is a central theme. It practices on-site composting, food donation, and repurposing leftovers reduce environmental impact. It is fostering social responsibility. Recycling and upcycling further demonstrate innovation, with hotels collaborating with local artisans to transform waste materials into usable or decorative items. It is creating both ecological and cultural value. Technologies solutions, wastewater recycling and digitalization for paper reduction, enhance operational efficiency while addressing SDGs 9 (Industry, Innovation, and Infrastructure) and 13 (Climate Action). At last, energy-efficient systems and comprehensive awareness campaigns ensure that sustainability is embedded into organizational culture and guest experiences. These strategies underscore the industry's evolving role in advancing urban sustainability goals through integrated waste reduction practices.

Hotels are adopting water-saving technologies and wastewater recycling systems, advancing SDG 6: Clean water and sanitation. Food waste initiatives, including composting and redistribution, convert waste into resources while addressing food insecurity, reinforcing SDG 2. Digitalization reduces paper use, advancing SDG 9 and SDG 13, while sustainable packaging supports SDG 12 and SDG 14. Staff and guest engagement initiatives promote shared responsibility (Rhou and Singal, 2020), aligned with SDG 4 and SDG 17: Partnership for the goals. Jointly, these strategies also improve hotels' alignment with SDG 11 (United Nations, 2015).

Table 6: Barriers and Challenges to Sustainable Waste management in Five-Star Hotels in Kolkata

Theme	Theme-related Content
Cost constraints	High Initial cost: implementing technologies like anaerobic digesters, composting units, and advanced recycling systems requires significant upfront investments. Ongoing operational Costs: These systems also incur ongoing expenses for maintenance energy consumption, and labour.
Lack of technical expertise	Technical expertise may be limited in-house, requiring external consultants. Training staff across departments is complex and costly.

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ISSN 2395-020X (P); e-ISSN 2583-2700 (O)
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Awareness and attitudinal challenges	Resistance to change may arise from a lack of awareness of potential benefits. The perception of waste as a low-priority issue hinders proactive waste reduction efforts.
Regulatory and policy issues	Policy Vacuum: lack of clear government policies and incentives. Regulatory Burden: overwhelming regulations without adequate support.
Space and infrastructure limitations	Space Limitations; urban hotels often lack the space for on-site waste processing. Infrastructure Deficiencies: external waste processing systems are unreliable.
Customer and stake holder expectations	Guest Awareness: guests may lack understanding of sustainable practices. Vender Alignment: suppliers may not fully align with sustainability goals.
Integration with existing practices	Transition challenges: Shifting to innovative waste management requires significant operational changes, leading to disruptions.

Source: Researchers' Primary Data

Findings (table 6) reveal that cost is most significant barriers to sustainable waste management in Kolkata five-star hotels. The application of advanced technologies, anaerobic digesters, and composting units, requires substantial initial investment, alongside high operational costs for maintenance, energy consumption, and labour. The lack of technical expertise within hotels is second barrier. Many hotels lack inhouse specialist. These organisations depend on external consultants. This technical deficiency obstructs the effective adoption of new systems and technologies that are critical for sustainable operations. Awareness and attitudinal challenges, challenge sustainability efforts. Some hotel staff and guests struggle due to limited awareness of the environmental and financial benefits of waste management practices. Waste itself is often perceived as a low-priority operational issue. This lack of engagement highlights the importance of fostering a sustainability-oriented culture within the hospitality industry.

The others critical challenges are regulatory and policy issues. Hotels report operating in a "policy vacuum" and limited institutional support. These barriers reduce the feasibility of scaling up sustainability waste management practices across the industry. Space and infrastructure limitations are basically evident in urban context like Kolkata. Luxury hotels frequently operate on compact land parcel. It is leaving insufficient room for on-site facilities such as composting units or recycling stations. Finally, customers and stakeholder expectation present unique challenges. Guest may lack understanding of sustainability practices.

They are perceiving them as inconveniences that diminish luxury experience. Although suppliers and vendors often fail to align with hotel sustainability goals.

These findings align with broader hospitality research. It emphasizes that financial, technical, cultural, and regulatory barriers intersect to slow sustainability adoption in urban luxury hotels. Addressing these challenges require coordinated action involving incentives, technological innovation, staff training, and stakeholder engagement. The most significant obstacles are cost constraints, lack of technical expertise, and operational space limitations. These challenges limits progression toward SDG 9 and SDG 11. Attitudinal barriers such as resistance to change among staff and guests reinforce these issues, hindering SDG 12. Also, the absence of supportive policy frameworks in India weakens the hospitality sector's ability to achieve sustainability goals. It is limiting SDG 16. To overcome these barriers, hotels need a multi-pronged approach. It integrates comprehensive training programs (SDG 4), regulatory incentives (SDG 16), vendor partnerships (SDG 17), and community engagement (SDG 11). Such holistic strategies can transform waste management challenges into opportunities for environmental and economic sustainability (SDG 8 and SDG 13) Rhou and Singal (2020).
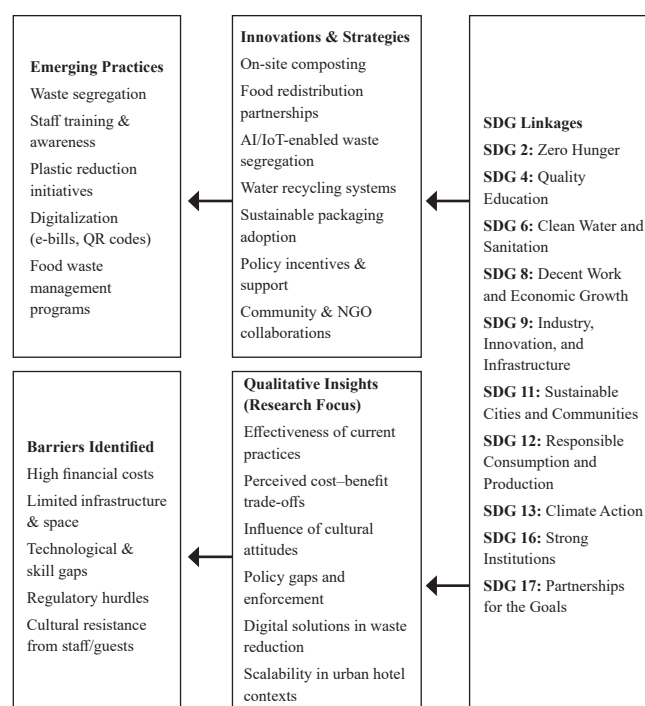

Figure 1: A Conceptual Model for Sustainable Waste Management in Hotels (Researchers' Own Model)

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ISSN 2395-020X (P); e-ISSN 2583-2700 (O)
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The conceptual model derived from this research illustrates emerging practices (segregation, training, plastic reduction, digitalization, and food waste programs), barriers (financial, infrastructural, technological, regulatory, and cultural), and potential innovations (composting, redistribution, AI/IoT systems, recycling, sustainable packaging, policy support, and partnerships). It also highlights qualitative insights that guide future research directions and connects these findings to broader SDGs. It is also demonstrating how hotel-level practices and challenges contributes to global sustainability.

Conclusion

There is complex challenge to pursue sustainable waste management in Kolkata's hotel industry. It is significant for doing positive environmental and economic impacts. There is a need to continue waste segregation, plastic reduction, and digital tools for waste sustainable. The findings reveal that financial constraints, technological limitations, inadequate infrastructure, and guest behaviours are major barriers foe sustainable waste management. To remove those barriers a multifaceted approach is necessary. To overcome, there is a need of robust government support, technological advancements, community engagement, and behavioural change programs. A sustainable circular economy model through integrating waste reduction, recycling, and resource recovery with broader sustainability initiatives can be established at hotel industry. Continuous monitoring, innovations, and collaboration among policy makers, industry stakeholders, and the community's involvement are helpful to ensure the long-term success of waste management in the hotel/hospitality industry. Hotel/Hospitality industry may change waste management into a keystone their sustainability strategy securing both environmental and economic benefits by addressing the issue of cost, infrastructure, and guest behaviour.

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